Inspection of Processed Photographic Record Films for Aging Blemishes

Handbook 96

United States Department of Commerce
National Bureau of Standards

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96	Inspection of Processed Photographic Record Films for Aging Blemishes	

* In preparation.

UNITED STATES DEPARTMENT OF COMMERCE • Luther H. Hodges, *Secretary*
NATIONAL BUREAU OF STANDARDS • A. V. Astin, *Director*

Inspection of Processed Photographic Record Films for Aging Blemishes

C. S. McCamy

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Foreword

Over the years the National Bureau of Standards has conducted considerable research on the permanence of record materials, including both paper and photographic film. Recently microscopic blemishes have been found on microfilms; apparently they had developed after the film was put in storage. Practically no information loss has been observed, but any potential threat to the permanence of Government records is a matter of concern not only to the National Bureau of Standards but to records officers throughout the Government. There is much to be learned from these blemishes and they are being studied in many laboratories.

This publication contains a description of the blemishes, illustrated with photomicrographs in color. It also describes methods used to inspect, sample, and report on the blemishes. It is felt that early publication of this information will serve to unify methods and terminology and thus aid in coordinating the various independent studies of the problem. This handbook should also provide the guidance needed for large-scale inspections of Government records.

A. V. Astin, *Director.*

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Inspection of Processed Photographic Record Films for Aging Blemishes

C. S. McCamy

Inspections of microfilms have recently revealed blemishes which apparently developed 2 to 20 years after the films were processed. Most of the blemishes are small spots, usually reddish or yellowish in color, ranging from about 15 to 150 microns across. These blemishes have been classified on the basis of size, shape, color, and character. This publication describes and gives colored illustrations of the various types, describes the method of observing them, and recommends sampling procedures for microfilm inspectors. The cause, the exact mechanism of formation of the various types, and generally accepted preventive measures are not as yet known. This publication is intended to promote uniform terminology, inspection, and reporting.

1. Introduction

Because of its ability to record a large amount of information in a small space and its stability relative to most record materials, photographic film is one of the most common media for the storage of records. A considerable percentage of United States Government records are stored on microfilm. Even though such films have been prepared by the best known techniques and stored in the best known manner, the only assurance that such records are being well maintained is a systematic program of careful inspection. Improper processing or storage conditions have long been known to promote general fading and various kinds of biological attack. Inspections of large numbers of rolls of microfilm recently have revealed several kinds of blemishes not heretofore noted. It appears that they have developed from 2 to 20 years after the film was processed and placed in storage. The blemishes have been classified on the basis of size, shape, color, and character. The purpose of this publication is to name and describe the various blemishes, to provide illustrations of them, to describe the method of observing them, and to recommend sampling procedures for microfilm inspectors. Although the chemistry and physics of these blemishes are under investigation at the National Bureau of Standards and in research laboratories in the photographic industry,[1] the causes of the blemishes, the exact mechanisms of their formation, and generally accepted preventive measures have not yet been established. A vital part of the research program is accurate reporting of blemishes, so that the incidence of the various types can be correlated with processing and storage variables. In this stage of the investigation, it cannot be expected that the types of blemishes described necessarily exhaust the possibilities, nor can the types be regarded as necessarily mutually exclusive.

[1] Henn, R. W. and Wiest, D. G. "Microscopic Spots in Processed Microfilm: Their Nature and Prevention." Phot. Sci. Eng. 7, 253, (1963).

2. Classification of Aging Blemishes

Type 1

Type 1 aging blemishes are circular spots, usually 50 to 150 microns in diameter, with sharp boundaries. Concentric light and dark rings are common. Spots normally occur as reduced density in high-density "background" areas, but may make incursions into low-density lines or characters. They are usually brown, orange, reddish, or yellow in color. It is common to find many spots about the same size on a sample. The circular boundaries of two or more spots may intersect. The spots are often seen centered on scratches in the emulsion, sometimes closely packed like beads on a string. They sometimes occur in higher concentration at steep density gradients between high- and low-density regions, sometimes being so closely packed as to give the appearance of a continuous band. By reflected light, the spots may display a silvery sheen.

Type 2

Type 2 are defects in the light lines forming the characters themselves, rather than in the high-density "background." The lines making up the characters become lighter, yellowish, and broader. The boundaries of the defect are sharp.

Type 3

Type 3 are very small spots, about 10 to 15 microns across. When they occur, there is usually a large number per unit of area. They usually range from pale yellow to orange in color. Their boundaries are sharp. By reflected light, the spots may display a silvery sheen.

Type 4

Type 4 blemishes are spots of less regular shape than type 1 but about the same size or a little larger, usually lighter in color, and less sharply bounded. A circular central "nucleus" is common.

These spots occur in high-density "background" areas. They do *not* make incursions on low-density characters; on the contrary, their shapes may be very distorted to accommodate to the spaces between characters or parts of characters.

Type 5

Type 5 is a reddening of the dark background in the immediate neighborhood of lighter characters. The boundaries of the discoloration are very diffuse. The shape is not regular, being determined by the shape of the characters or line of characters with which the discoloration is associated.

Type 6

Type 6 is a reddish, orange, or yellow spot of reduced density, lightest at the center and gradually blending into the surrounding background. An irregular opaque or crystalline particle is commonly observed on the surface of the film at the center of the spot. The sizes of the spots may vary considerably, even within a small region.

3. Sampling Method

The first task is to divide the films into separate homogeneous groups, called "strata" in statistical sampling theory. These groups must be distinguished by differences which may be chemically or physically significant. Examples of such differences are differences in processing, differences in storage conditions, differences in film size, and differences in film type. Differences in textual content, i.e., differences in the kinds of documents photographed, may coincide with or assist in determining significant differences but are not, in themselves, of primary value in establishing separate strata. Careful attention to defining the strata to be sampled may eventually lead to the discovery of the factors upon which the formation of these blemishes depends. Once the strata have been well defined, the number of rolls in each should be ascertained.

In some cases, it may be desirable to inspect every roll of film in a stratum. This procedure may be feasible if the group is not too large, but in many cases the number of rolls makes total inspection impractical. In such cases a sample is taken from the stratum.

To be representative of the group, the sample must contain a sufficient number of rolls. The sample should be 1/1000 of the stratum but not less than 100 rolls. The whole group should be inspected if there are less than 100 rolls. This minimum sample size is based upon the desired accuracy of the estimate of total incidence as derived from the sample. The accuracy of the determination does not increase in proportion to the increase in the size of sample. Thus, additional expenditure of time and effort beyond the minimum is hardly justified.

It is necessary that sampling procedures be established which will assure that all parts of the stratum are represented. For example, if 100 rolls are to be selected from 300 drawers, 1 roll might be taken from every third drawer. Each roll should be taken from the center or some other easily identifiable position in the drawer. The establishment of the sampling pattern in advance prevents an inspector from consciously or unconsciously introducing a bias in the sampling by selecting rolls which have some distinguishing characteristic. On each roll of the sample, the whole leader, about 6 ft of the information frames adjoining the leader, and about 6 ft near the center of the roll should be inspected.

4. Inspection Methods and Equipment

Although some aging blemishes are visible to the unaided eye, it has been found necessary to use a microscope to inspect films for their presence. The very versatile instruments recently introduced by the optical industry have greatly facilitated microfilm inspections. An instrument which has been very useful is a low-power stereo microscope with continuous magnification adjustment. The magnification is continuously variable from 7× to 30×. The components of the microscope can be arranged so that the column supporting the optics is away from the inspector. This permits the inspector to place the center of a long roll of film on the stage from the side of the instrument facing him.

The film on the microscope stage is illuminated by either of two light sources which can be turned on and off independently. A small fluorescent light source with a flat diffusing surface is used to illuminate the stage from below when the film is to be viewed by transmitted light. The clarity of the image may be improved by placing a circular paper aperture directly under the stage glass, to prevent light from getting into the microscope from angles outside the field of view. The aperture should be just slightly larger than the field of view at the lowest magnification. The second illuminator is a small spotlight which is used to illuminate the stage from above, usually at a nearly grazing angle. This source is used to view the surface of the film by reflected light and is particularly useful for detecting objects or materials on the film surface or defects in the surface.

For convenience, the stage of the microscope may be equipped with guides to hold the film in viewing position but permit the film to be advanced and rewound easily. Figures 9 and 13 illustrate how

such guides can be made. The guide has two plastic rails attached by screws to a metal base. The plastic rails have grooves in which the edges of the film slide. If the screw holes through one of the rails are elongated, the spacing between the rails can be adjusted. Then the dimensions are not critical and the machining does not have to be precise. The dimensions for 16 and 35 mm film guides are given in table 1. Dimensions *b* and *c* are based upon the assumption that the grooves in the two rails are of equal depth.

Rewinds should be placed at either side of the microscope so that a roll of film can be placed on one and be taken up on the other. To avoid damaging the film, the inspector should wear cotton gloves (available from suppliers of photographic materials), the film should be handled by its edges only, inspecting equipment should be designed to avoid scratching the film, and the equipment must be kept clean. To avoid contaminating the film with chemical dust, film should be inspected in an area well removed from any area where film is processed or chemicals are handled.

TABLE 1. *Dimensions for film guide*

Dimensions (refer to fig. 13)	Nominal film width	
	16 mm	35 mm
a	65 ± 10 mm	65 ± 10 mm
b	16.5 ± 0.3 mm	35.5 ± 0.3 mm
c	14.0 ± 0.3 mm	31.0 ± 0.3 mm
d	0.7 ± 0.3 mm	0.7 ± 0.3 mm
e	2.5 ± 1 mm	2.5 ± 1 mm
f	6.5 ± 2 mm	6.5 ± 2 mm
g	6.5 ± 2 mm	6.5 ± 2 mm
h	45 ± 5 mm	45 ± 5 mm
i	75 ± 10 mm	75 ± 10 mm

TABLE 2. *Severity classification of spot blemishes*

Severity	Concentration in spots per cm ^{2}
1	less than 1
2	1 to 8
3	8 to 63
4	63 to 500
5	over 500

5. Reporting

The incidence of a type of blemish can be indicated by the percent of rolls affected, but this gives no indication of severity. In recording severity, it has been found necessary to consider the blemishes of two major kinds: *spot blemishes* (types 1, 3, 4, and 6) and *character-associated blemishes* (types 2 and 5).

The concentration of *spot blemishes* may be indicated by the number of spots per square centimeter. In practice this might be the number of spots in the field of view with a particular instrument at a given magnification. The diameter of the field of view can be measured easily by placing a millimeter scale on the stage. The area can then be computed. The instrument most often used in the preliminary survey had a field 20 mm in diameter when the magnification was 10. The inspector soon learned to recognize on sight any one of five degrees of severity defined in table 2.

The concentration, in spots per square centimeter, is not a true measure of the severity of character-associated blemishes because the concentration is dependent upon the number, size, and shape of the characters. A severity classification based upon the effect of the blemishes on the information content of the document has been devised. This classification should have some relevance for the technical study of the phenomenon and is based upon criteria of utmost concern to those involved with the practical matter of maintaining records. For convenience in tabulating the data, a scale of five degrees of severity has been defined to correspond to the five degrees of severity of spot-type blemishes. The definitions of the five degrees of severity are given in table 3.

Because of the spectral nature of the blemishes and the spectral sensitivity of photographic materials, the legibility of characters affected by type 2 blemishes is often very much better on a photographic copy than it is on the original negative film. The inspector can nearly simulate this effect

TABLE 3. *Severity classification of character-associated blemishes*

1	Blemishes barely detectable, have no effect on the original shape and size of the characters.
2	Blemishes clearly visible, coloration change clearly visible, but shape and size of characters unchanged.
3	Blemishes well developed. Lines or parts of lines making up characters changed, but general shape of characters is unchanged. (See, for example, figs. 3 and 5.)
4	Blemishes have altered the shape and size of characters to the extent that individual characters could not be identified with certainty out of context. Characters can be identified in context.
5	Blemishes have so altered the size and shape of characters that they cannot be identified with certainty even in context. This constitutes information loss, on a given roll, in the practical sense. Information from other rolls of microfilm should not be considered part of the context.

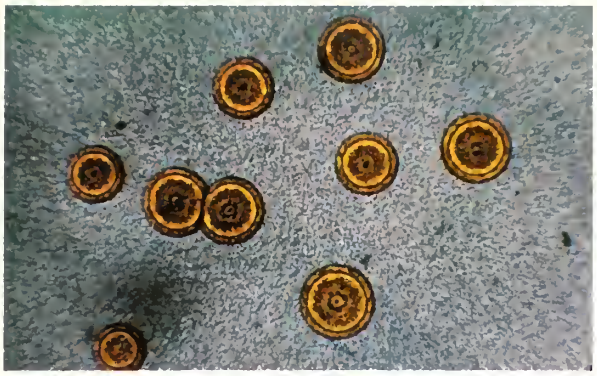
by viewing the original negative microfilm through a Wratten No. 47 blue filter. A similar increase in legibility is generally obtained with type 5 blemishes by viewing the original microfilm through a Wratten No. 29 red filter. Since these filters transmit only a small percent of the light, it may be necessary to increase the illumination when the filters are used. If characters can be identified with certainty by the use of filters, they should be considered identified with certainty for purposes of ascertaining the severity of the blemishes.

The most desirable kind of report may differ from agency to agency, and the factors of interest may change as the investigation of aging blemishes progresses. Some of the factors which have been recorded in the early stages of the investigation and which might continue to be of interest are:

roll identification (enough to locate roll later),
date of inspection,
film width in millimeters,
name of film manufacturer,
brand name of film,
type of base material,
date of manufacture of film,
date of film processing,
name of firm or agency which processed film,
type of storage can or carton,
type of reel,
range of storage temperature,
range of relative humidity in storage area,
kind of air conditioning (filtering, washing, etc.),
location of storage area (basement, for example),
use of humidification trays in storage cabinets,
whether leader was fogged or clear,
presence of splices,
frequency and type of splices,
some indication of activity of collection (such as dead storage, infrequent use, daily use),
presence of bands or strings around roll,
visual evidence of chemical residues,
presence of silvery sheen on fogged leader and other dense areas (on large areas of surface rather than just on spots),
evidence of general discoloration or fading,
presence of water spots,
incidence of various types of aging blemishes,
severity of blemishes,
blemishes of kinds not listed in this publication,
indication of correlation between incidence of blemishes and some other characteristic.

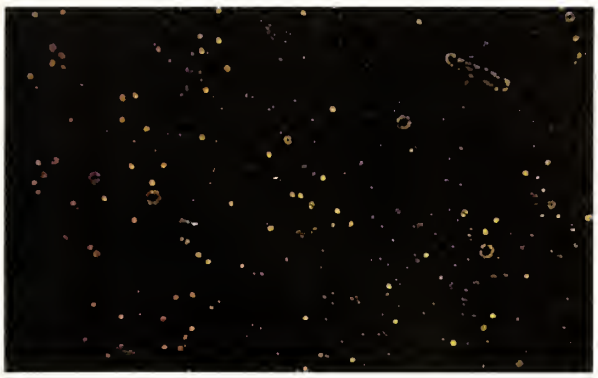
The summary of data on each stratum should include the following information of technical interest: name of stratum, location, date of inspection, name of inspector, number of rolls in stratum, number of rolls in sample, percent of rolls in sample having each kind of blemish on leader, percent of rolls in sample having each kind of blemish on information frames, and other data which appear to be indicative of strong correlations. Agencies may require other information for accounting and administrative purposes.

For counsel on the statistical sampling procedure, the author is grateful to Dr. W. J. Youden. The photomicrographs, so essential to a publication of this kind, were made by Mr. Myron Berkovitz. Miss Anna-Mary Bush did the bulk of the inspection in the preliminary program and devised the working definitions of the degrees of severity of spot-type blemishes on the basis of field of view. The author acknowledges with gratitude many exchanges of information with scientists at the Eastman Kodak Company who first identified and classified types 1, 2, and 3. The author appreciates the help of records officers in many Government agencies who have cooperated with the Bureau on this project by permitting access to records and providing research materials for the laboratory.



1

2



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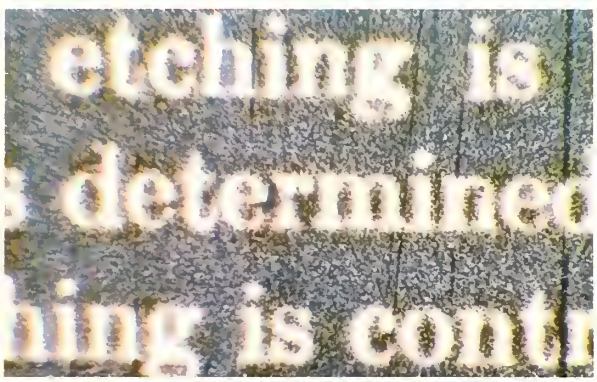

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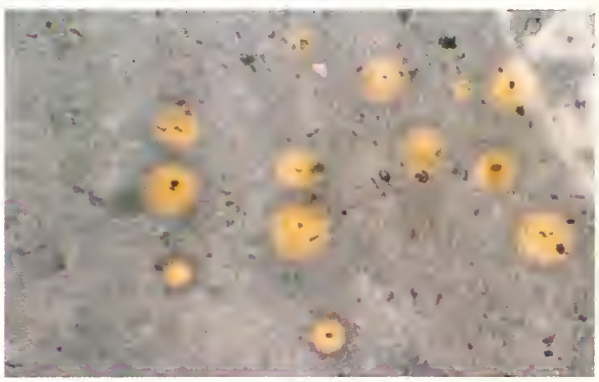

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FIGURE 1. *Type 1*. On the record film, the spots shown range from 120 to 170 microns in diameter.
FIGURE 2. *Type 2*. On the record film, the height of the numbers is 180 microns.
FIGURE 3. *Type 3*. On the record film, the spots are about 15 microns across.
FIGURE 4. *Type 4*. On the record film, the height of the numbers is 240 microns.
FIGURE 5. *Type 5*. On the record film, the height of the lower case letters is 120 microns.
FIGURE 6. *Type 6*. On the record film, these spots range from 30 to 110 microns in diameter.

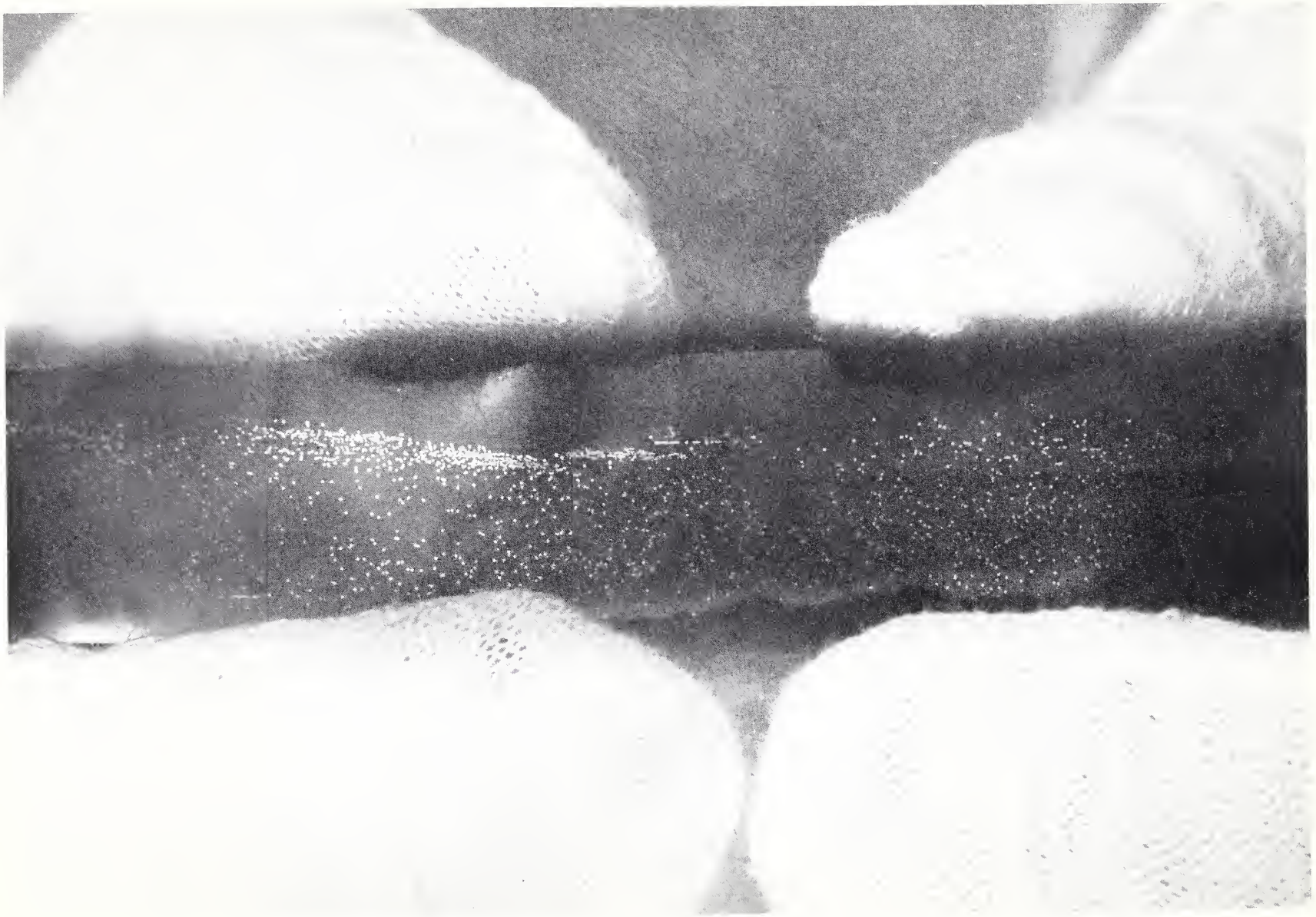


FIGURE 7. *Some spots can be seen with the unaided eye.* Here the silvery sheen of type 1 is seen on a 16 mm fogged leader by reflected light.

FIGURE 8. *The inspection of film for aging blemishes requires a binocular microscope with a magnification ranging from about 7 to about 30 times, substage illuminator, "spotlight" illuminator, rewinds, cotton gloves, and a clean working space.*

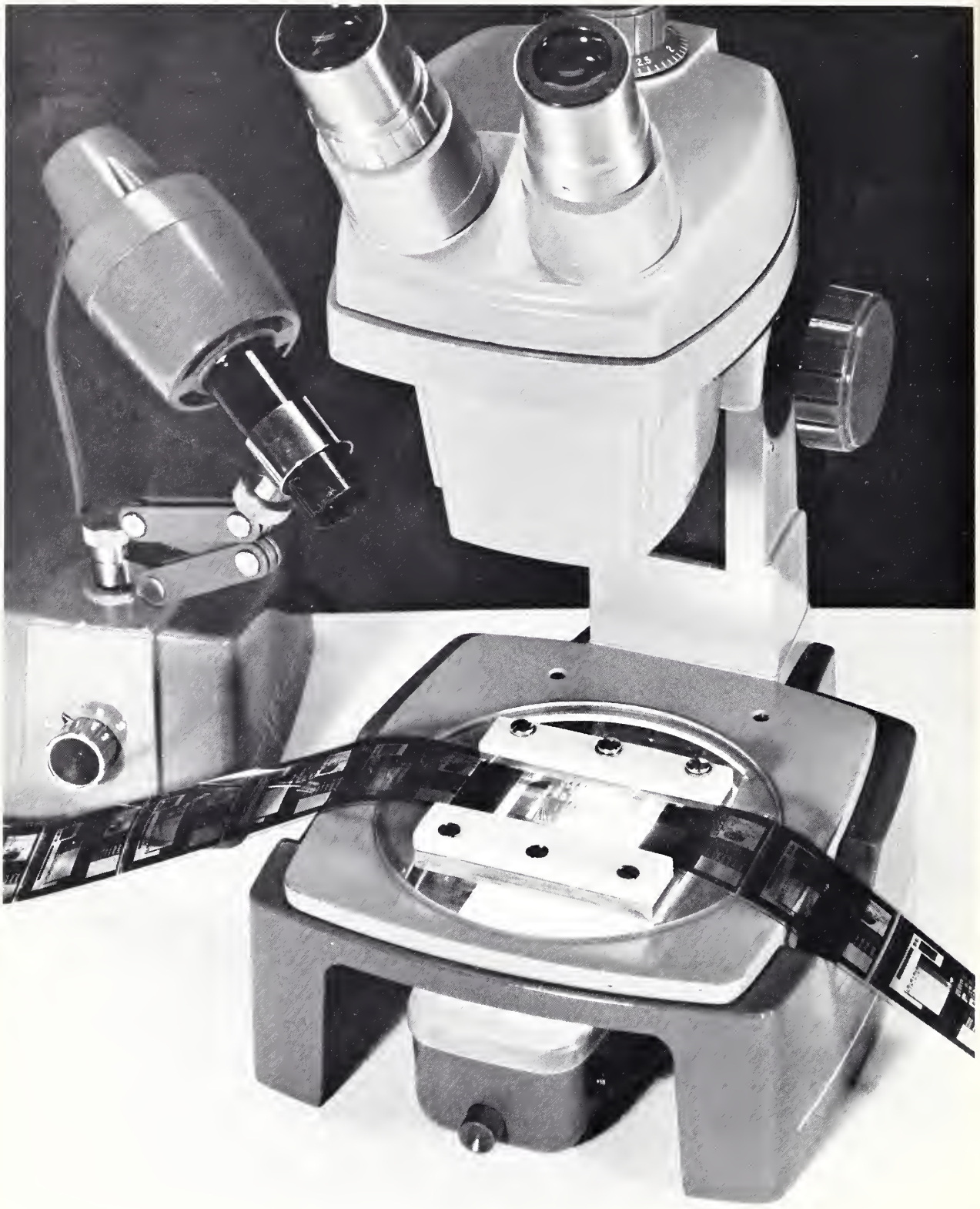


FIGURE 9. *Microscope with illumination for viewing by transmitted light.*

FIGURE 10. *Microscope with illumination for viewing by reflected light.*

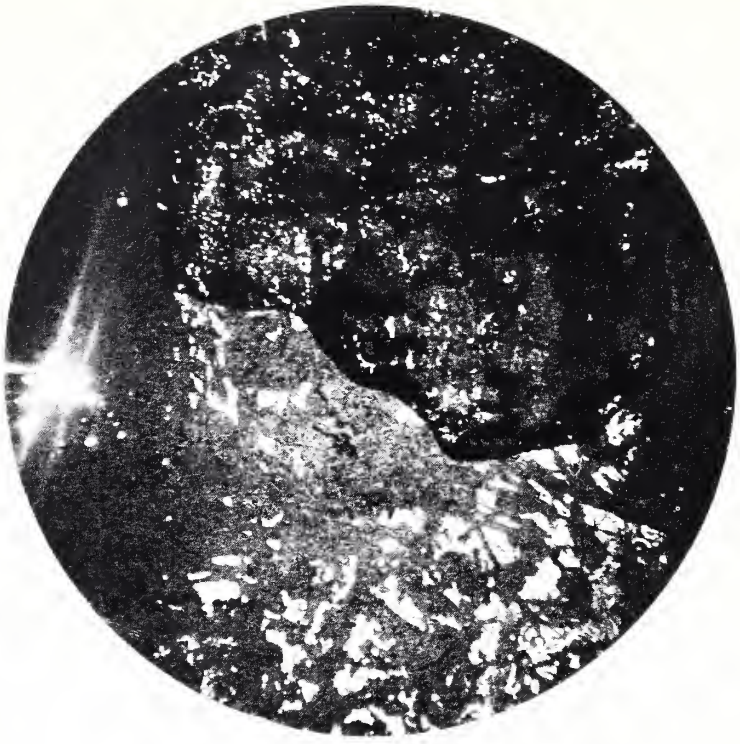
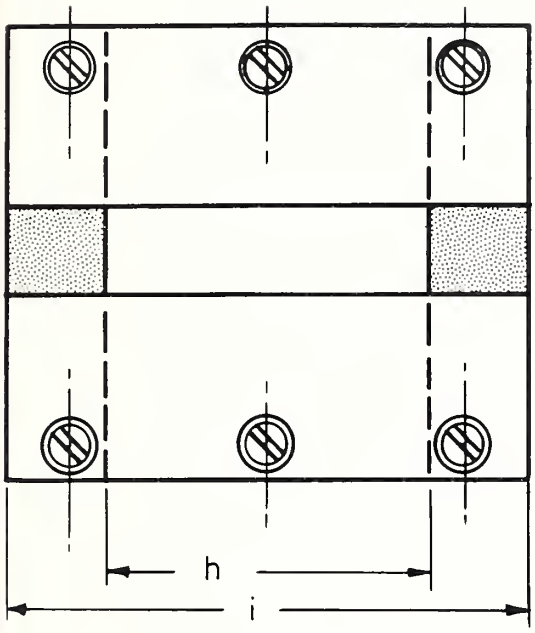
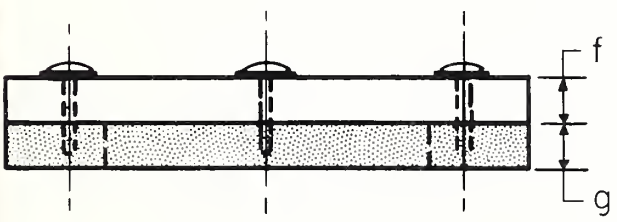


FIGURE 11. *View by transmitted light.* Differences in transmittance are made visible.

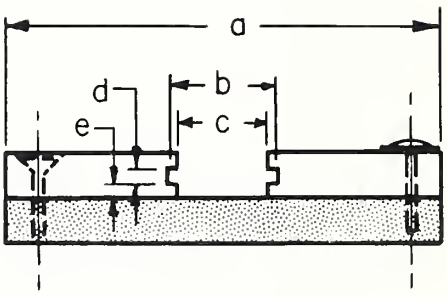
FIGURE 12. *View by reflected light.* Differences in reflectance, irregularities of the surface, and foreign matter on the surface are made visible.



TOP VIEW



SIDE VIEW



END VIEW

FIGURE 13. *Film guide for use on the microscope stage.* Dimensions are given in the text.

Dec 05, 2017